New biosensor benefits from melding of carbon nanotubes, DNA

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Purdue University scientists have developed a method for stacking synthetic DNA and carbon nanotubes onto a biosensor electrode, a development that may lead to more accurate measurements for research related to diabetes and other diseases.

Standard sensors employ metal electrodes coated with enzymes that react with compounds and produce an electrical signal that can be measured. But the inefficiency of those sensors leads to imperfect measurements.

Carbon nanotubes, cylindrically shaped carbon molecules known to have excellent thermal and electrical properties, have been seen as a possibility for improving sensor performance. The problem is that the materials are not fully compatible with water, which limits their application in biological fluids.

Marshall Porterfield, a professor of agricultural and biological engineering and biomedical engineering, and Jong Hyun Choi, an assistant professor of mechanical engineering, have found a solution. Their findings, reported in the journal *The Analyst*, describe a sensor that essentially builds itself.

"In the future, we will be able to create a DNA sequence that is complementary to the carbon nanotubes and is compatible with specific biosensor enzymes for the many different compounds we want to measure," Porterfield said. "It will be a self-assembling platform for biosensors at the biomolecular level."

Choi developed a synthetic DNA that will attach to the surface of the carbon nanotubes and make them more water-soluble.

"Once the carbon nanotubes are in a solution, you only have to place the electrode into the solution and charge it. The carbon nanotubes will then coat the surface," Choi said.

The electrode coated with carbon nanotubes will attract the enzymes to finish the sensor's assembly.

The sensor described in the findings was designed for glucose. But Porterfield said it could be easily adapted for various compounds.

"You could mass produce these sensors for diabetes, for example, for insulin management for diabetic patients," Porterfield said.

Porterfield said it may one day be possible to develop other sensors using this technology that could lead to more personalized medicines that could test in real time the effectiveness of drugs on their targets as with cancer patients.

Porterfield said he would continue to develop biosensors to detect different compounds.

More information: Microbiosensors Based on DNA Modified Single-Walled Carbon Nanotube and Pt Black Nanocomposites, *The Analyst*.

Abstract
Glucose and ATP biosensors have important applications in diagnostics and research. Biosensors based on conventional materials suffer from low sensitivity and low spatial resolution. Our previous work has shown that combining single-walled carbon nanotubes (SWCNTs) with Pt nanoparticles can significantly enhance the performance of electrochemical biosensors. The immobilization of SWCNTs on biosensors remains challenging due to the aqueous insolubility originating from van der Waals forces. In this study, we used single-stranded DNA (ssDNA) to modify SWCNTs to increase solubility in water. This allowed us to explore new schemes of combining ssDNA-SWCNT and Pt black in aqueous media systems. The result is a nanocomposite with enhanced biosensor performance. The surface morphology, electroactive surface area, and electrocatalytic performance of different fabrication

protocols were studied and compared. The ssDNA-SWCNT/Pt black nanocomposite constructed by a layered scheme proved most effective in terms of biosensor activity. The key feature of this protocol is the exploitation of ssDNA-SWCNTs as molecular templates for Pt black electrodeposition. The glucose and ATP microbiosensors fabricated on this platform exhibited high sensitivity (817.3 nA/mM and 45.6 nA/mM, respectively), wide linear range (up to 7 mM and 510 ?M), low limit of detection (1 ?M and 2 ?M) and desirable selectivity. This work is significant to biosensor development because this is the first demonstration of ssDNA-SWCNT/Pt black nanocomposite as a platform for constructing both single-enzyme and multi-enzyme biosensors for physiological applications.

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